Enabling a transition to electric mobility in public transport fleets: Policies and Enabling Environment

Asia LEDS Partnership Clean Mobility Community of Practice

First online Session

22nd June 2018

www.ledsgp.org
www.asialeds.org

The Low Emission Development Strategies (LEDs) Global Partnership was founded in 2011 to enhance coordination, information exchange, and cooperation among countries and international programs working to advance low emission climate resilient growth. The LEDs Global Partnership currently brings together LEDs leaders and practitioners from more than 120 countries and international institutions through innovative peer learning and collaboration forums and networks. For the full list of participants and more information on partnership activities, see ledsgp.org.
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**Agenda**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Speaker(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 minutes</td>
<td>Welcome and introduction to mobility CoP</td>
<td>Anandhan, ALP</td>
</tr>
<tr>
<td>10 minutes</td>
<td>Participant introductions</td>
<td>All</td>
</tr>
<tr>
<td>40 minutes</td>
<td>Discussion on ‘Enabling a transition to electric mobility in public transport fleets: Policies and enabling environment’</td>
<td>Cabell Hodge, NREL</td>
</tr>
<tr>
<td>40 minutes</td>
<td>Country presentation and discussions</td>
<td>Country representatives, Cabell Hodge, ALP</td>
</tr>
<tr>
<td>10 minutes</td>
<td>Open discussion</td>
<td>All</td>
</tr>
<tr>
<td>10 minutes</td>
<td>Closing remarks and next steps</td>
<td>Avantika, ALP</td>
</tr>
</tbody>
</table>
Introducing Asia LEDS Partnership
Clean Mobility Community of Practice

Anandhan, Asia LEDS Partnership
Asia LEDS Partnership

ALP is a regional platform under the LEDS Global Partnership,

- Comprised of over **885 members (611 individuals and 274 organizations)** from the **public, private, and non-governmental sectors** active in designing, promoting, and/or implementing LEDS in Asia

Objectives:

- Facilitate enhanced **coordination, collaboration, and partnerships**
- Identify and disseminate **tools, models, approaches, and best practices** in priority Low Emission Development Strategies topics to enable peer-to-peer learning and application
- Foster **capacity building** of practitioners to make Asia a leader in designing and implementing LEDS and green growth
- Strengthen support for LEDS by catalyzing **leaders of change and raising awareness** about the benefits of LEDS
ALP priority topics for 2018-2019

- **Grid Scale Renewable Energy**
  - Building Blocks for Grid Renewable Energy Development
  - Renewable Energy Grid Integration

- **Clean Mobility**
  - Focus on usage of clean fuels, electric mobility, technology and creation of supporting infrastructure
  - Policy and regulatory framework for public transport along with involvement of private sector

- **Clean Energy Finance**
  - Lowering the cost and risk of capital
  - Attracting private finance through smart policy and enabling environments

- **Multi-level Governance**
Mobility Community of Practice

- An interactive network of national and subnational governments, technical institutions, transport experts addressing real-time policy, financing and technical challenges and solutions related to cleaner mobility.

- Mobility CoP is a platform for
  - sustained engagement among countries for learning and technical collaboration
  - continuous access to tools and expert assistance

Designed to be demand driven to meet members’ needs and will offer support and solutions to early movers as needs emerge.

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What Mobility CoP offers to its members?

Focus on peer learning, knowledge exchange, and expert assistance

Opportunities for countries to learn from each other and from experts on specific elements of Cleaner transport

- Topic specific online sessions to include country and expert presentations
- Open discussions on each country’s challenges and approaches
- Regional peer learning and training workshops

Learning resources or compilation of tools, resources, training materials, case studies, good practices

Country government participants will have access to no-cost technical assistance to support RE planning and development; Deep dive support to early mover Countries.
Public Transportation Fleets: Bus Electrification

Enabling a transition to electric mobility in public transport fleets: Policies and Enabling Environment

Cabell Hodge, NREL
National Renewable Energy Laboratory

Laboratory owned by U.S. Department of Energy with 40 years of research into science and engineering of renewable energy and integrated transportation systems.
NREL Support for Bus Electrification

Research and development
- Battery technologies, powertrain development, thermal management

3rd party evaluation
- Established evaluation protocol
- Unbiased data in common format

Technical consultant
- Provide feedback to governments on technical and policy challenges
- Partner with the transit industry on technology and market

Fleet assessments
- Economic and operational assessments of battery and fuel cell electric buses
- Developing charging strategies
- Comparison to baseline technology (e.g. diesel)

https://www.nrel.gov/transportation/index.html
Presentation Outline

Types of electric buses
Planning considerations
Policies to support deployment
Types of Electric Buses:

- Fuel Cell Electric Buses
- Depot Charge Battery Electric Buses
- On-Route Charge Battery Electric Buses
Fuel Cell Electric Buses

Pros
- No need for added buses to meet service
- Depot logistics and parking like conventional buses
- Fueling similar to conventional buses

Cons
- Requires hydrogen fueling station
- Facility needs modification for maintaining gaseous fueled buses
- Current hydrogen costs can be high ($5-$13/kg)
- More complex systems
Fuel Cell Electric Bus Fueling

- Similar fueling experience to gas/diesel
- Requires high pressure compression
Depot Charge Battery Electric Buses

**Pros**
- Off-peak charging with potentially lower electricity rates
- Centralized charging equipment
- Availability of standardized chargers
- Can add on-route inductive charging for longer range
- Charging handled by maintenance staff

**Cons**
- Typically requires larger on-board battery packs
- Need multiple chargers at depot
- Plan for logistics for operating buses in the parking area
- Charging time longer
- May require mid-day charge
- May require more buses to meet service
On-Route Charge Battery Electric Buses

**Pros**
- All day operation with smaller pack
- Depot logistics and parking like conventional buses
- One fast-charge station can serve multiple routes

**Cons**
- Cost of fast-charger installation
- Routes limited by charger location
- Potential for demand charges
- Difference manufacturers provide different types of chargers
- May require more buses to meet service
### Bus Charging Strategies

- Power and charging speed for Proterra buses

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>PROterra® Power Control System 60kW</th>
<th>PROterra® Power Control System 125kW</th>
<th>PROterra® Power Control System 500kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Power Level Available (kW)</td>
<td>60</td>
<td>125</td>
<td>500</td>
</tr>
<tr>
<td>PCS Location</td>
<td>Depot</td>
<td>Depot</td>
<td>Depot / Onroute</td>
</tr>
<tr>
<td>Dispenser Type</td>
<td>Plug in / Overhead</td>
<td>Plug in / Overhead</td>
<td>Overhead</td>
</tr>
<tr>
<td>Connection Standard</td>
<td>J1772 CCS Plug In J3105 Inverted Pantograph</td>
<td>J1772 CCS Plug In J3105 Inverted Pantograph</td>
<td>J3105 Inverted Pantograph</td>
</tr>
<tr>
<td>VEHICLES</td>
<td>FC</td>
<td>FC+</td>
<td></td>
</tr>
<tr>
<td>Charging Time or Mileage Per Charge*</td>
<td>1.1 hours</td>
<td>0.9 hours</td>
<td>19 miles per 10 minutes</td>
</tr>
<tr>
<td></td>
<td>FC+</td>
<td>1.5 hours</td>
<td>0.7 hours</td>
</tr>
<tr>
<td></td>
<td>XR</td>
<td>2.9 hours</td>
<td>2.4 hours</td>
</tr>
<tr>
<td></td>
<td>XR+</td>
<td>4.4 hours</td>
<td>2.4 hours</td>
</tr>
<tr>
<td></td>
<td>E2</td>
<td>5.9 hours</td>
<td>2.8 hours</td>
</tr>
<tr>
<td></td>
<td>E2+</td>
<td>7.3 hours</td>
<td>3.5 hours</td>
</tr>
<tr>
<td></td>
<td>E2 MAX</td>
<td>8.8 hours</td>
<td>4.2 hours</td>
</tr>
</tbody>
</table>

*Efficiencies based on DuoPower drivetrain; FC series charges at max overhead power limit; XR/E2 series charges at continuous power limit for plug-in; all charge times are approximate.*

[https://www.proterra.com/technology/chargers/](https://www.proterra.com/technology/chargers/)
U.S Market for Zero Emission Buses

Manufacturer Options for Zero Emission Buses Available in United States

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Max Seating</th>
<th>ZEB Type</th>
<th>Battery Size (kWh)</th>
<th>Range (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYD</td>
<td>25-60</td>
<td>BEB</td>
<td>90-180 x2</td>
<td>144-200</td>
</tr>
<tr>
<td>eBus</td>
<td>22</td>
<td>BEB</td>
<td>130</td>
<td>125</td>
</tr>
<tr>
<td>ELDorado National</td>
<td>33</td>
<td>FCEB</td>
<td>11 + 150 (FC)</td>
<td>&gt;300</td>
</tr>
<tr>
<td>GreenPower Bus</td>
<td>25-100</td>
<td>BEB</td>
<td>210-478</td>
<td>175-240</td>
</tr>
<tr>
<td>New Flyer</td>
<td>32-61</td>
<td>BEB</td>
<td>150-600</td>
<td>&gt;200</td>
</tr>
<tr>
<td>New Flyer</td>
<td>32-61</td>
<td>FCEB</td>
<td>700 - 1100*</td>
<td>&gt;300</td>
</tr>
<tr>
<td>Nova Bus</td>
<td>41</td>
<td>BEB</td>
<td>76</td>
<td>25</td>
</tr>
<tr>
<td>Proterra</td>
<td>40</td>
<td>BEB</td>
<td>94-660</td>
<td>55-426</td>
</tr>
</tbody>
</table>

- Manufacturers offer range of electric bus configurations
  - Depot overnight charging
  - On-route fast charging
  - Swappable battery packs
  - Fuel cell electric buses are not listed but have been on the market for longer than most battery electric buses
Battery Electric Bus
Planning Considerations
Bus Range Considerations

• Develop bus specifications to meet operational requirements
• Select bus type and charging strategy
• Modeling and simulation tools are helpful to make informed choices
  – NREL uses Trip Recorders and FASTSim to model motor and battery needs
Infrastructure Considerations

• Depot bus placement of chargers
  – Space limitations
  – One charger for multiple buses: move cords instead of buses
  – Logistics for moving buses through property will be affected by placement of chargers and need for access to chargers

• Electrical upgrades
  – Transformers, distribution and service panels, trenches, conduit, conductors
  – Managed charging solutions

• Scalability
  – Plan initial infrastructure for potential scale up

Access for permanent trenching
Power Cost Considerations

- Understand power needs and electricity rate structure for better planning
  - Monthly fixed costs
  - Energy consumption rates
  - Peak demand charges → Can be particularly high for fast chargers
  - Time of use rates → Off-peak and on-peak
  - Summer verses winter rates

1. On-Peak, Mid-Peak, and Off-Peak charge categories include respective costs for delivery and generation
2. Rate structure changed from TOU-GS-1-A to TOU-EV-4 February 2016, introducing demand charges
3. ‘Taxes, Fees & Credits’ category includes all remaining utility bill items (positive & negative charges)
Operational Considerations

Labor requirements
- Manual charging and maintenance
- Scale requirements with number of depots

Optimize operation
- Consider charging needs, downtime, and bus schedules
- Might require extra buses

Training
- Docking procedures
- Aggressive driving impacts range
- Plan for continual training based on driver turnover

Power outages
- Depending on grid reliability, backup power or distributed generation may be preferable
Maintenance Considerations

Warranties

- During warranty period, on-site bus manufacturer staff usually handle repairs for advanced systems while transit staff handle preventive maintenance

Training

- Work with bus manufacturer to provide initial training
- Training for working on high voltage electric systems
- Consider need for follow-up training with changes in staff

Tools

- Special tools for troubleshooting and diagnosing issues

Parts list
Battery Electric Bus Deployments
Foothill Transit Deployment

- Battery electric bus service start: April 2014
- NREL evaluation through 2020
- Baseline comparison: 42-foot NABI compressed natural gas buses

<table>
<thead>
<tr>
<th>FCEB Identifier</th>
<th>BEB 35FC</th>
<th>BEB 40FC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Buses</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Bus Manufacturer</td>
<td>Proterra</td>
<td>Proterra</td>
</tr>
<tr>
<td>Bus model</td>
<td>BE 35</td>
<td>Catalyst</td>
</tr>
<tr>
<td>Bus length/height</td>
<td>35 ft / 129 in</td>
<td>42.5 ft / 134 in</td>
</tr>
<tr>
<td>Charging strategy</td>
<td>Fast-charge, on-route</td>
<td>Fast-charge, on-route</td>
</tr>
<tr>
<td>Motor</td>
<td>Permanent magnet, UQM, PP220</td>
<td>Permanent magnet, UQM, PP220</td>
</tr>
<tr>
<td>Rated Power (kW)</td>
<td>220 (peak)</td>
<td>220 (peak)</td>
</tr>
<tr>
<td>Energy Storage, type</td>
<td>Lithium-titanate</td>
<td>Lithium-titanate</td>
</tr>
<tr>
<td>Capacity</td>
<td>368 volts, 88 kWh</td>
<td>331 volts, 106 kWh</td>
</tr>
</tbody>
</table>
Foothill Bus Availability

BEB 35FC Fleet
- Available: 88.9%
- Other categories: 1.2%, 2.5%, 6.2%
Date Range: Apr 2014 - Dec 2017
Days Planned: 11,781

BEB 40FC Fleet
- Available: 81.3%
- ESS: 18.0%
Date Range: Jan 2017 - Dec 2017
Days Planned: 411

CNG Fleet
- Available: 96.8%
- Other categories: 1.2%, 3.9%
Date Range: Oct 2014 - Dec 2017
Days Planned: 5,409

Data labels omitted for pie slices representing < 1.0%
• Total battery electric bus 35FC maintenance cost since 2014 was $0.26/mi including an issue with low voltage batteries; without low voltage battery cost $0.24/mi
• CNG bus maintenance cost was $0.22/mi
### Foothill Bus Fuel Economy

#### Overall 2017

<table>
<thead>
<tr>
<th>Bus</th>
<th>kWh/mi, mpgge</th>
<th>mpdge</th>
<th>kWh/mi, mpgge</th>
<th>mpdge</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEB 35FC</td>
<td>2.18</td>
<td>17.28</td>
<td>2.18</td>
<td>17.24</td>
</tr>
<tr>
<td>BEB 40FC</td>
<td>2.22</td>
<td>16.99</td>
<td>2.22</td>
<td>16.99</td>
</tr>
<tr>
<td>CNG</td>
<td>3.86</td>
<td>4.32</td>
<td>3.71</td>
<td>4.15</td>
</tr>
</tbody>
</table>

mpgge = miles per gasoline gallon equivalent  
mpdge = miles per diesel gallon equivalent
Lessons Learned

Infrastructure is key

• Need comprehensive charging strategy, especially for more than 5-10 buses
• Transit company must work closely with utility and manufacturers

Cost of driver turnover

• Additional training on docking procedure for the fast charge station

Maintenance costs

• Learning curve when warranty period ends
King County Metro Deployment

- Battery electric bus in-service date: April 2016
- 3 Proterra, 40-foot Catalyst buses and fast charging station
- Baseline buses: diesel, diesel hybrid, and electric trolley buses
- Full year of data completed in April 2017
- Report in final publication

<table>
<thead>
<tr>
<th>FCEB Identifier</th>
<th>BEB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Buses</td>
<td>3</td>
</tr>
<tr>
<td>Bus Manufacturer</td>
<td>Proterra</td>
</tr>
<tr>
<td>Bus length/height</td>
<td>40 ft / 126 in</td>
</tr>
<tr>
<td>Charging strategy</td>
<td>Fast-charge, on-route</td>
</tr>
<tr>
<td>Motor</td>
<td>Permanent magnet, UQM, PP220</td>
</tr>
<tr>
<td>Rated Power (kW)</td>
<td>220 (peak)</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>Lithium-titanate</td>
</tr>
<tr>
<td>Capacity</td>
<td>331 volts, 106 kWh</td>
</tr>
</tbody>
</table>
Average fuel economy corresponds to monthly temperature
- High of 17.6 mpdge in September 2016 to a low of 13.3 mpdge in December 2016
- Overall average fuel economy for the data period was 15.9 mpdge
Expensive electricity can lead to higher fuel costs per mile than diesel, despite efficiency improvements.
### Maintenance Cost per Mile by System

<table>
<thead>
<tr>
<th>System</th>
<th>BEB</th>
<th>Hybrid</th>
<th>Diesel</th>
<th>Trolley</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost/mi ($)</td>
<td>Percent of Total (%)</td>
<td>Cost/mi ($)</td>
<td>Percent of Total (%)</td>
</tr>
<tr>
<td>Propulsion-related</td>
<td>0.05</td>
<td>18.6</td>
<td>0.12</td>
<td>38.0</td>
</tr>
<tr>
<td>Cab, body, and accessories</td>
<td>0.13</td>
<td>49.7</td>
<td>0.12</td>
<td>36.7</td>
</tr>
<tr>
<td>Preventive maintenance (PM)</td>
<td>0.03</td>
<td>10.8</td>
<td>0.04</td>
<td>12.0</td>
</tr>
<tr>
<td>Brakes</td>
<td>0.01</td>
<td>4.5</td>
<td>0.01</td>
<td>2.2</td>
</tr>
<tr>
<td>Frame, steering, and suspension</td>
<td>0.00</td>
<td>1.0</td>
<td>0.01</td>
<td>2.2</td>
</tr>
<tr>
<td>Heating, ventilation, air conditioning</td>
<td>0.01</td>
<td>4.4</td>
<td>0.01</td>
<td>2.9</td>
</tr>
<tr>
<td>Lighting</td>
<td>0.01</td>
<td>2.7</td>
<td>0.01</td>
<td>1.7</td>
</tr>
<tr>
<td>General air system repairs</td>
<td>0.01</td>
<td>4.1</td>
<td>0.01</td>
<td>3.2</td>
</tr>
<tr>
<td>Axles, wheels, and drive shaft</td>
<td>0.00</td>
<td>0.0</td>
<td>0.00</td>
<td>0.3</td>
</tr>
<tr>
<td>Tires</td>
<td>0.01</td>
<td>4.1</td>
<td>0.00</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.26</strong></td>
<td><strong>100</strong></td>
<td><strong>0.32</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

- Signiﬁcant maintenance savings compared to diesel buses in King County
## Lessons Learned

### Charger availability
- Availability of the on-route fast-charger is critical

### Operator training
- Docking procedures
- Returning buses with full charge

### Operations planning
- Bus range may limit selection of routes
- Routes with more stops can better capitalize on regenerative braking
- Planned layover may include charging, but limits layover flexibility

### Parts list for inventory
- Common issue limiting functional time
Surat Bus Analysis

- Data collection for battery electric bus analysis underway in Surat, India
- Primary focus on bus rapid transit system
  - Set routes, timetables, and no traffic create more consistency for routes
  - Surat already employs “Smart City” infrastructure and captures extensive data from buses
  - Useful data points include km driven, fuel consumption, GPS track, auxiliary loads such as air conditioning, and passenger load
Policies to Support Bus Electrification
Barriers to Adoption

Initial cost is significantly higher than diesel buses

Charging infrastructure installation costs money and requires planning

Peak demand charges can drive up electricity costs

Operators and maintenance staff are unfamiliar with electric bus technology
Initial Costs

• All buses are expensive and battery electric buses are more so

<table>
<thead>
<tr>
<th>Year</th>
<th>Diesel</th>
<th>CNG</th>
<th>Low NOx CNG</th>
<th>Diesel Hybrid</th>
<th>Battery electric (depot charge)</th>
<th>Battery electric (on-route charge)</th>
<th>Fuel Cell Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>480,000</td>
<td>520,000</td>
<td>540,000</td>
<td>690,000</td>
<td>770,000</td>
<td>750,000</td>
<td>1,235,000</td>
</tr>
<tr>
<td>2017</td>
<td>491,260</td>
<td>532,198</td>
<td>552,667</td>
<td>706,186</td>
<td>754,187</td>
<td>733,062</td>
<td>1,100,000</td>
</tr>
<tr>
<td>2018</td>
<td>502,783</td>
<td>544,682</td>
<td>565,631</td>
<td>722,751</td>
<td>738,374</td>
<td>716,124</td>
<td>1,050,000</td>
</tr>
</tbody>
</table>

Source: Advanced Clean Transit – California Air Resources Board

• Upfront subsidies can ease burden
  – India offers up to $146,600 per bus as well as money for charging infrastructure
  – Some Chinese cities offer up to $150,000
  – California offers up to $175,000 for specified articulated buses

• Leasing arrangements can stretch costs over time
Charging Infrastructure

- **Develop most cost-effective charging strategy that meets operational needs**
  - Consider time parked overnight, route consistency over the next decade, and cost differential between depot charge buses and on-route charge buses
  - Plan for long-term scale
  - Minimize installation costs
  - Cost drivers include concrete trenching and transformers

- **Charging management solutions**
  - Share chargers among buses
  - Networked solutions can charge buses on first-in, first-out basis or share power to minimize power demand and infrastructure upgrades
Peek Demand Charges

- **Costs of charging may depend on speed of charging and time of day**
  - Bus power demand can reach 500 kW per charger
  - Demand costs sometimes exceed 90% of charging costs in US
- **Electricity rates**
  - Examine whether transit company pays peak demand costs
  - Utility policies can exclude electric vehicles from demand costs
  - Time-of-use rates can incentivize charging at certain times
- **Manage charging**
  - Stagger charging through route scheduling or network solution
  - Charge during low time-of-use cost periods
  - Bidirectional charging can be effective solution for buses due to large batteries and predictable schedules

Zhang et al., NREL, *Value to the Grid from Managed Charging Based on California’s High Renewables Study*
Train Staff

On-route charging

• Docking at overhead lines or wireless charging pads requires special training
• Return buses to base fully charged

Depot charging

• Drivers should monitor battery capacity and ensure sufficient range
• Manual charging of buses

Maintenance

• Consider warranty options from manufacturers
• May require staff training by manufacturer and/or in another city or country
Example of Success: Shenzen, China

- Started small and grew to 100% electric buses in 6 years
- 48% reduction in CO2e compared to diesel buses
- Policies used to promote adoption:
  - $150,000 subsidy per bus
  - Leasing to reduce upfront costs
  - Coordinated charging strategy: one charging port for every three buses
  - Lifetime warranties on traction batteries

### Foothill Maintenance Cost per Mile by System

<table>
<thead>
<tr>
<th>System</th>
<th>BEB 35FC</th>
<th>CNG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost per Mile ($)</td>
<td>Percent of Total (%)</td>
</tr>
<tr>
<td>Propulsion-related</td>
<td>0.05</td>
<td>19</td>
</tr>
<tr>
<td>Cab, body, and accessories</td>
<td>0.05</td>
<td>18</td>
</tr>
<tr>
<td>Preventive maintenance (PM)</td>
<td>0.07</td>
<td>29</td>
</tr>
<tr>
<td>Brakes</td>
<td>0.00</td>
<td>2</td>
</tr>
<tr>
<td>Frame, steering, and suspension</td>
<td>0.00</td>
<td>1</td>
</tr>
<tr>
<td>Heating, ventilation, and air conditioning</td>
<td>0.00</td>
<td>1</td>
</tr>
<tr>
<td>Lighting</td>
<td>0.01</td>
<td>3</td>
</tr>
<tr>
<td>Air, general</td>
<td>0.00</td>
<td>1</td>
</tr>
<tr>
<td>Axles, wheels, and drive shaft</td>
<td>0.01</td>
<td>3</td>
</tr>
<tr>
<td>Tires</td>
<td>0.06</td>
<td>23</td>
</tr>
<tr>
<td>Towing charges</td>
<td>0.01</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.26</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

- Summary of costs from start of service
- Highest cost systems for the BEBs were: PM; tires; and Propulsion-related
- Highest cost systems for the CNG buses were: Propulsion-related; PM; and Cab, Body, and Accessories
King County Availability

Battery Fleet Availability
- 80.6%
  - Available: 4.8%
  - Bus: 2.1%
  - PM: 12.1%

Hybrid Fleet Availability
- 90.5%
  - Available: 1.1%
  - Electric Drive: 6.9%

Diesel Fleet Availability
- 86.4%
  - Available: 1.2%
  - Engine: 11.5%

Trolley Fleet Availability
- 84.9%
  - Available: 3.7%
  - Current Collection: 3.9%
  - Hybrid System: 1.3%

Legend:
- Blue: Available
- Green: Bus Maintenance
- White: PM
- Orange: Electric Drive
- Blue: ESS
- Purple: Charging Issues
- Yellow: Current Collection
- Pink: Hybrid System
- Gray: Trans
- Beige: Engine

1. Data period for availability analysis: Aug 2016 - Jul 2017
2. Labels removed from pie slices representing < 1%
The Low Emission Development Strategies (LEDS) Global Partnership was founded in 2011 to enhance coordination, information exchange, and cooperation among countries and international programs working to advance low emission climate resilient growth. The LEDS Global Partnership currently brings together LEDS leaders and practitioners from more than 120 countries and international institutions through innovative peer learning and collaboration forums and networks. For the full list of participants and more information on partnership activities, see ledsgp.org.

Bhutan

Mr. Leki Choda, Road safety and transport authority, Bhutan
Initiatives being taken by Bhutan to promote electrification of buses

- Currently we do not have any electric buses in the country
- We focus on improving public transport buses in the country
- We have around more than 200 buses plying in the country from one district to district
- Our Plan is to Promote the use of public transport shifting from the use of private cars as mode of transportation
- We have the electric vehicle initiatives going on in the country but very doubtful of the success
Current challenges that are inhibiting Bhutan from optimizing/ reaching the target goal

- Infeasibility
- Affordability
- Reliability
The Low Emission Development Strategies (LEDS) Global Partnership was founded in 2011 to enhance coordination, information exchange, and cooperation among countries and international programs working to advance low emission climate resilient growth. The LEDS Global Partnership currently brings together LEDS leaders and practitioners from more than 120 countries and international institutions through innovative peer learning and collaboration forums and networks. For the full list of participants and more information on partnership activities, see ledsgp.org.

Sri Lanka

Mr. Kularatne, Director, Ministry of Planning and Civil aviation
Initiatives being taken by Sri Lanka to promote electrification of buses

1. Ministry of finance has allocated Rs.500 million in 2018 budget to purchase electric bus for improvement of transport service of Sri Lanka transport board. Accordingly ministry of transport is doing procurement procedure.

2. In 2018 budget finance ministry has imposed tax concession for the electric vehicles. 50% concession for electric cars

3. By 2025 bus fleet has to be electrified. Priority is given to the electric buses.
Current challenges that are inhibiting Sri Lanka from optimizing/ reaching the target goal

1. Lack of electricity generation

2. Lack of infrastructure facilities (charging stations, Bus stations, road construction, payment card system etc)

3. Need of Technical capacity development and trainings

4. Lack of financial resources
Electric Vehicles and Public Transport in the Philippines

Joyce, Road Transport and Infrastructure, Department of Transportation
Government Efforts

Philippine Environmentally Sustainable Transport Strategy (GOP)
Executive Order 488 S. 2006 (Senate)
Department Order 2011-16 (DOTr)
Electronic & Hybrid Vehicles Including Charging Stations Promotions Act 2016 (DOTr)
Promotion of Low-Carbon Urban Transport Systems in the Philippines (DOTr, UNDP)
Public Utility Vehicle Modernization Program (DOTr)
Separation of E-Vehicles in the Motor Registration Process (LTFRB)
Allowing Fare Increase of 20% to E-Vehicles Operating as PUVs (LTO)
Various House and Senate Bills

Preference  Priority  Fiscal Incentives

Common Theme
Success Stories

Star-8 Electric Jeepneys in Tacloban as part of the PUV Modernization Program.

Green Frog Hybrid Bus in Makati City.
Discussions
Closing and next steps

• Technical assistance
• Keep in touch
• Share with your peers
• Survey questions
Thank you!

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